Remarks

Thorough examination by the Examiner is noted and appreciated.

The Specification has been amended to correct grammatical and typographical errors.

The claims have been amended and new claims added to better clarify Applicants claimed invention.

Support for the amended claims is found in the original claims and/or Specification. No new matter has been entered.

For example, support for claim amendments in claims 1, 10, and 23 are found in originally presented claims e.g., claims 2, 11, and 14. The nitrogen to oxygen ratios in new claims 26 and 27 are found in claims 9 and 19.

The claims have been clarified by limiting the claims to hydrogen containing fluorocarbons consistent with the disclosed etching gases e.g., CHF_3 and C_4F_8, C_5F_8, or C_4F_6, also presented in new claims 21 and 22, finding support in the Specification. In addition, other limitations, such as optionally adding oxygen

(claim 1) and etching the etch stop layer in the absence of oxygen (claims 20 and 23) are found at the following excerpted portions:

See paragraph 0029 beginning on page 14:

"For instance, for the first etching step as shown in Figure 1A where the DARC is first etched through it has been found that fluorocarbons or **hydrofluorocarbons represented herein as C_xF_y** containing a nitrogen to oxygen ratio of at least 5 had a good etching selectivity of the DARC layer 10 (e.g., SiON) to the photoresist 12."

See paragraph 0034 beginning on page 17:

"Similar to etching the DARC layer, it has been found that a high nitrogen level in the ambient is likewise beneficial to etching low-k materials. It has been found that nitrogen flow rates of about 100 sccm to about 300 sccm with a nitrogen to oxygen ratio of at least about 10 gives good etching results according to the present invention. **As with DARC etching, it has been found that etching may proceed with unexpectedly improved results with high nitrogen to oxygen ratios and even in the absence of oxygen.** However, it has also been found that the presence of some oxygen is preferable in that control of critical dimension bias may be effected."

See paragraph 0036 beginning on page 18:

"Hydrofluorocarbons such as C_4F_8, C_5F_8, **or** C_4F_6,or a mixture thereof is provided at an increased carbon to fluorine ratio of at least about ½ (i.e. a decreased suitable fluorine to carbon ratio of at least about 2) is preferably supplied with a flow rate from about 5 to about 15 sccm."

See also paragraph 0037 on page 19:

"Turning to Figure 3c, a third step in an etching process is depicted whereby etching is continued through the low-k dielectric layer 14 to an etch stop layer 16 or what is commonly known in the art as an over-etching step. For this process it has been found that for the final period of etching, whereby the low-k dielectric layer 14 is etched through to the underlying etch stop layer 16, **it is preferable if no oxygen is present** in the ambient plasma etch as it has been found that etching selectivity for the etch stop layer is diminished. Thus, it is preferable according to the present invention that etching through the final part of the low-k dielectric layer 14 is carried out in the absence of oxygen."

Claim Rejections under 35 USC 103(a)

Claims 1-20 stand rejected under 35 USC 103(a) as being unpatentable over Liu et al. (US 6,346,474 B1) in view of Oehrlein (US 6,060,400).

Liu discloses a process for creating a dual damascene structure without an etch stop (see Abstract). Liu et al.

disclose a plasma etch recipe for etching through an etch mask layer disclosed to be either SiN or SiON (col 3, lines 5-9). Specifically Liu et al. disclose a process where by a via etching mask is first formed in the etch mask layer followed by etching through a portion of the IMD layer to form a portion of a via opening followed by etching a trench etching mask in the etch mask layer followed by etching the trench opening in the IMD layer while extending the depth of the via opening (col 5, lines 15-50). Liu discloses using CF_4 (col 5, lines 55-59) CHF_3/CO or CH_3F/CO to etch through the etch mask (nitride layer) (see col 3, lines 42-45) and discloses using C_4F_8/CO to etch through the IMD layer (see col 5, lines 31-35).

Liu significantly does not disclose using nitrogen or oxygen nor discloses a nitrogen to oxygen ratio as disclosed and claimed by Applicants in claims 1 and 23 nor discloses nor discloses a fluorine to carbon ratio as disclosed and claimed by Applicants in claims 10 and 23.

Oehrlein et al. disclose a remote plasma process for removing (stripping) silicon nitride masks over silicon dioxide or silicon (see Abstract). The etching method of Oehrlein et al. uses high rates of oxygen flow in addition to a source of

fluorine so that oxidation of silicon is favored over etching of silicon (see col 2, lines 25-30). The method of Oehrlein et al. is disclosed for solving the problem of stripping a silicon nitride layer over silicon (see col 1, lines 36-45) (without an overlying patterned photoresist layer) which would not be expected to be successful in the method of either Liu or in Applicants disclosed and claimed invention. Oehrlein et al. does not recognize or discuss the problem of an etching selectivity with respect to a patterned photoresist layer. Oehrlein et al. further discloses a nitrogen to oxygen ratio directly contrary to Applicants disclosed and claimed invention. For example, Oehrlein et al. teach an oxygen content **greater** than a nitrogen content which would be expected to have poor etching selectivity with respect to photoresist. Specifically, Oehrlein et al. teach an oxygen flow rate in the range of 250-5000 sccm and a nitrogen flow rate in the range of 25 - 5000 sccm (col 2, lines 41-45) which corresponds to a nitrogen to oxygen flow ratio of .005 to 1 to 4 to 1 thereby outside Applicants claimed ranges and teaching away from Applicants claimed invention and further, destroying the principal of operation of Applicants invention. Oehrlein et al. also discloses a flow ratio of oxygen to a fluorine source (disclosed to be CF_4 or NF_3) of 20 to 1 or greater (see col 2, lines 35-40) which is directly contrary to

Applicants claimed plasma operating conditions in claims 9 and 19, further teaching away from Applicants claimed invention.

There is no apparent reason for combining Liu and Oehrlein et al. since Oehrlein et al. disclose a method for stripping silicon nitride overlying silicon or silicon oxide to improve an etching selectivity of silicon nitride with respect to silicon or silicon oxide **without a resist layer present** and Liu discloses a method for etching through a silicon nitride or silicon oxynitride etch mask layer with an overlying patterned resist layer for improving **an etching selectively of silicon oxide with respect to silicon nitride and resist**. There is no reason for expecting that the process of Oehrlein et al. could be adopted or be successful in the method of Liu. Nevertheless, such combination does not produce Applicants claimed invention, Liu not disclosing the use of nitrogen or oxygen and Oehrlein et al. 's disclosed nitrogen to oxygen ratios for accomplishing an entirely different etching process being far outside Applicants claimed ranges.

For example Applicants disclose a nitrogen to oxygen ratio of at least about 5 in etching a nitride layer (claim 1) and at least about 10 (claim 10)in etching an IMD layer. Applicants

also claim flow rates having a flow rate ratio of nitrogen to oxygen of 5 to 1 to about 150 to 1 for etching a nitride layer and 15 to 1 to about 150 to 1 for etching a low-K carbon containing dielectric material (see claims 9, 19, 26 and 27). Further neither Oehrlein et al. nor Liu disclose a desired fluorine to carbon ratio for etching a low-K carbon containing IMD layer, Liu disclosing using CHF_3 (3:1) or CH_3F (1:1), and Oehrlein et al. disclosing CF4 (4:1) compared to Applicants disclosed and claimed fluorine to carbon ration within a range of 2 to about 3 (see claim 10, claim 23).

With respect to claim 20, neither Liu nor Oehrlein et al. disclose carrying out a plasma etching process using hydrogen containing fluorocarbons and nitrogen to etch through an etch stop layer where oxygen is not added during the etching process as claimed by Applicants.

Examiner argues that "Oehrlein also teaches that it is known to vary the amount of oxygen and nitrogen in a fluorocarbon plasma (col 4, lines 26-41)" and therefore "it would have been still further obvious to add oxygen to an ambient of nitrogen and fluorocarbon and adjust the nitrogen to oxygen ratio to five because the ratio appears to be a result effective variable".

In order for Examiner to rely on a result effective variable, Examiner must show the general conditions of Applicants claimed invention in the prior art where patentability is dependent on the claimed ranges. *In re Woodruff 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936, (Fed Cir 1990.* "A particular parameter must first be recognized as a result-effective variable, i.e., a variable which achieves a recognized result, before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation." *In re Antonie*, 559 F.2d 618, 195 USPQ 6 (CCPA 1977)

Examiner has not shown the general conditions of Applicants disclosed and claimed invention. Moreover, even assuming *arguendo* that Examiner has shown the general conditions Applicants claimed invention, which have not been shown, the result effective variable argument may be overcome by a showing the ranges are critical or achieve an unexpected result. *In re Woodruff 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936, (Fed Cir 1990)*. In the instant case, for example, Applicants have pointed out in the Specification the criticality of the nitrogen to oxygen ratio and have pointed to unexpected results. Nevertheless, Examiner has not shown the general conditions in the prior art since the modification of Liu with Oehrlein et al.

would not be expected to work in the method of Liu, and further, such modification does not produce Applicants invention.

"If the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims prima facie obvious." *In re Ratti, 270 F.2d 810, 123, USPQ 349 (CCPA 1959).*

Applicants point out that "we do not pick and choose among the individual elements of assorted prior art references to recreate the claimed invention, but rather we look for some teaching or suggestion in the references to support their use in a particular claimed combination" *Symbol Technologies, Inc. v. Opticon, Inc., 935 F.2d 1569, 19 USPQ2d 1241 (Fed. Cir. 1991).*

Since Examiner has not shown a *prima facie* case of obviousness with respect to the independent claims, neither has a *prima facie* case of obviousness been shown for the dependent claims.

The Claims have been amended to clarify Applicants claimed invention and new Claims added. A favorable consideration of Applicants' claims is respectfully requested.

Based on the foregoing, Applicants respectfully submit that the Claims are now in condition for allowance. Such favorable action by the Examiner at an early date is respectfully solicited.

In the event that the present invention as claimed is not in a condition for allowance for any other reasons, the Examiner is respectfully invited to call the Applicants' representative at his Bloomfield Hills, Michigan office at (248) 540-4040 such that necessary action may be taken to place the application in a condition for allowance.

Respectfully submitted,

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